UNITED NATIONS

GENERAL ASSEMBLY

Distr.
GENERAL

A/AC.105/560/Add.1
26 May 1994

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

REPORT ON THE THIRD UNITED NATIONS/EUROPEAN SPACE AGENCY WORKSHOP ON BASIC SPACE SCIENCE FOR DEVELOPING COUNTRIES, ORGANIZED IN COOPERATION WITH THE GOVERNMENT OF NIGERIA AND HOSTED BY THE UNIVERSITY OF NIGERIA, NSUKKA, AND THE OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE

(Lagos, Nigeria, 18-22 October 1993)

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INTRODUCTION

A. Background and objectives

1. The General Assembly, at its thirty-seventh session, adopted resolution 37/90 of 10 December 1982, endorsing the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) that the United Nations Programme on Space Applications should promote the growth of indigenous nuclei and an autonomous technological base in space technology in developing countries. At its thirty-fifth session, in June 1992, the Committee on the Peaceful Uses of Outer Space endorsed the United Nations Programme on Space Applications for 1993 as recommended by the Scientific and Technical Subcommittee of the Committee at its twenty-ninth session. Subsequently, the General Assembly, by resolution 47/67, endorsed the activities of the Programme on Space Applications for 1993.

2. The Third United Nations/European Space Agency Workshop on Basic Space Science for Developing Countries was part of the 1993 activities of the Programme on Space Applications. The Workshop was co-sponsored by the European Space Agency (ESA), German Space Agency (DARA), International Centre for Theoretical Physics (ICTP), National Aeronautics and Space Administration (NASA), Nigerian Telecommunications PLC (NITEL), and The Planetary Society (TPS), organized in cooperation with the Government of Nigeria through its National Agency for Science and Engineering Infrastructure (NASENI), and hosted by the University of Nigeria, Nsukka, and the Obafemi Awolowo University, Ile-Ife, Nigeria, from 18 to 22 October 1993.

3. The objective of the Workshop was to strengthen basic space science in developing countries by addressing the ways and mechanisms through which the following goals could be accomplished:

(a) To improve the awareness of scientists of current and future scientific and technical aspects of basic space science;

(b) To enhance scientific cooperation among developing countries;

(c) To explore avenues of education, training and research on basic space science subjects for the benefit of developing countries;

(d) To create on international core group of scientists to pursue the objectives of the Workshop.

4. The present report, which covers the background, objectives and organization of the Workshop, as well as giving a summary of presentations (see annex I to the present report), observations and recommendations made at the Workshop, has been prepared for the United Nations Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Subcommittee. Participants in the Workshop will report to appropriate authorities of the Government, universities and research institutes in their respective countries.

B. Organization and programme of the Workshop

5. Invitations to participate in the Workshop were sent by the United Nations to scientific professionals with substantial experience in one or more of the following areas; (a) international cooperation in basic space science; (b) education for space science; (c) atmospheric physics; (d) planetary science; (e) binary star astronomy; (f) solar physics; (g) ground-based and space-based astronomy; and (h) astrophysics and cosmology. The Workshop was attended by 54 scientists from 15 countries and 7 national and international organizations: Argentina, Austria, Canada, Colombia, Germany, Ghana, Honduras, India, Italy, Kenya,

Nigeria, South Africa, Spain, Thailand, United States of America; and the United Nations, ESA, DARA, ICTP, NASA, NITEL and TPS.

6. Funds allocated by the United Nations, ESA, DARA, ICTP, NASA, NITEL and TPS, for the organization of the Workshop were used to cover the cost of international air travel and daily subsistence allowance for 18 participants from 14 countries. The Government of Nigeria provided the Workshop facilities and local transportation for the duration of the Workshop, and room and board.

7. In Lagos, welcoming addresses were made by Prof. G. O. Ezekwe, Vice Chairman of NASENI; Chief Dapo Sarumi, Honourable Secretary for Communications, on behalf of the Government of Nigeria; Profs. O. K. Audile and W. Omole, Vice-Chancellors of the University of Nigeria and Obafemi Awolowo University; Mr. E. C. Omeata, on behalf of the Chief Executive and Managing Director of NITEL; and Dr. A. A. Abiodun, Expert on Space Applications, on behalf of the United Nations.

8. The scientific programme of the Workshop (see annex II to the present report) was developed by the United Nations Office for Outer Space Affairs, in collaboration with the European Space Agency, The Planetary Society and the University of Nigeria, Nsukka. The Workshop was scheduled to have five days of plenary and working group sessions with presentations by invited speakers only. The Workshop sessions were held in an informal style, leaving enough time for informal discussions and a few ad hoc contributions from participants. The morning of Friday, 22 October, was exclusively reserved for Working Group sessions in which participants discussed in depth the national capabilities to develop programmes and to undertake research activities in basic space science and ways to foster international collaboration in the field. The proceedings of the Workshop will be published in the Conference Proceedings series of the American Institute of Physics (AIP), New York.

OBSERVATIONS AND RECOMMENDATIONS

A. Basic space science

9. In order to assist scientists in developing countries in finding the necessary support in the pursuit of basic space science, great efforts should be made to create awareness of the importance of basic space science for national development among decision makers and the general public. In reconsidering the suggestions contained in the reports of the first and second United Nations/European Space Agency Workshop on Basic Space Science for Developing Countries, held in India, in 1991 (A/AC.105/489), and in Costa Rica and Colombia, in 1992 (A/AC.105/530), participants wish to highlight that the goals associated with basic space science in Africa are related to the desire to educate their own basic space scientists as well as the engineers, managers and technicians needed for self-reliant development and management of the resources of the continent through the tools and knowledge acquired in the pursuit of basic space sciences as defined by the following areas of research: (a) astronomy and astrophysics; (b) solar-terrestrial interaction and its influence on terrestrial climate; (c) planetary and atmospheric studies; and (d) origin of life and exobiology.

10. Participants agreed that the following techniques would be applicable for pursuing basic space science research:

(a) Ground-based optical, infrared and radio observations and radio and optical telescopes with associated equipment;

(b) Remote sensing, both from the ground and from space;

(c) In situ measurements from rocket, balloon and satellite platforms;

(d) All measurements from ground-inaccessible windows (e.g. X-ray and others) which could be made only through the use of instruments and telescopes in Earth orbit;

(e) Phased radar techniques.

B. Availability and dissemination of scientific information

1. Access to information

11. Major space agencies of the world should be urged to supply advanced information regarding various projects to scientists in developing countries so that those scientists may involve themselves in follow-up studies.

12. Considering the very high price of scientific journals and the recognized disadvantage associated with the unavailability at a professional level of information on front-line research in all countries associated with the previous workshops, it is recommended that all research groups interested in basic space science should request assistance in contacting publishers with a view to investigating mechanisms that would enhance worldwide availability of such journals.

13. In view of the severe difficulties encountered by researchers in acquiring textbooks, conference proceedings and other materials needed for advanced scientific research, efforts should be made to ensure the printing, in association with activities already being carried out by the International Astronomical Union (IAU), ICTP, European Physical Society (EPS) and AIP, of textbooks in English on basic space science at the elementary, primary, secondary and undergraduate levels, as well as popular texts on basic space science in that language.

2. Data archives and data centres

14. The participants emphasized the importance of the availability at the national level of existing basic space science data archives for building up first-rate educational and research capabilities for internationally recognized scientific investigations.

15. Member States are urged to select, through national discussion, local or regional clearing-houses for the highly valuable data archives that are still available at no cost from their producing agencies. The owners should be requested to deliver such data products in a manner conducive to easy dissemination and access at the national level, e.g. COBE skymaps, ROSAT survey data, International Ultraviolet Explorer (IUE), Uniform Low Dispersion Archive (ULDA) and Planetary Data System (PDS). Those clearing-houses (or data centres) would foster the development of national basic space science resources and stimulate international collaboration by the existence of centres of common interest. They would also make highly valued data pertaining to individual countries more accessible to other countries, and consequently enhance awareness of the capabilities of each country.

16. Existing or planned centres are strongly recommended to open their facilities beyond national borders to support and stimulate regional access, which is considered to be mutually beneficial and will stimulate development at a regional level, making use of the services of ROSTA.

3. Information management system

17. The participants noted that the United Nations had consulted with institutes and researchers concerning the availability of the above-mentioned information and the collection of detailed information on bilateral and

multilateral arrangements allowing an exchange of students and researchers for learning as well as teaching purposes. A document containing that information was distributed at the meeting.

18. Recognizing that a country's level of involvement in the activities in basic space science is invariably associated with existing economic conditions, the participants recommended the development of new initiatives in developing countries for deeper involvement in basic space science. They recognized, however, that such new initiatives should be accommodated within the existing individual infrastructure of the country. They also recognized the importance of exploring ways and means by which the evolution of individual countries' basic space science activities and international cooperation could be maintained and stimulated.

19. The introduction of basic space science in the university curriculum is an important tool for development, since its multidisciplinary nature will allow an independent mechanism to maintain and stimulate the development process.

4. Electronic communication network

20. The participants recognize that the rapid pace of change in basic space science and technology makes the free and efficient flow of ideas and concepts a prime need for participation in basic space science, and therefore urged Member States to plan and implement local electronic communication at or above the level of E-mail networks. Once implemented, or even before the existence of a local (national) network, an INTERNET connection should be established at a suitable location.

21. It is especially desirable to realize the regional importance of such central connections, since this will more than any other investment stimulate regional development by communications between scientists with common interests, to address regionally associated problems with far higher efficiency.

22. Member States should identify requirements without which the above-mentioned facilities cannot be implemented and should identify and possibly provide the minimum necessary investment to start implementation.

5. Use of available scientific databases

23. The participants recognize the importance of access to advanced instrumentation and modern extended data sets for the evolution of basic space science disciplines and urge Member States and their scientists to utilize those facilities that are currently available. Much of this could be accomplished by the utilization of existing available databases (such as those available for IUE and EXOSAT and that have now become available from the planetary missions), but additional direct use of these facilities would add critical impetus to the development of institutions currently unfamiliar with these facilities.

24. The distribution and acquisition of software, especially in relation to the techniques related to data acquisition, data reduction, image processing and physical modelling, which has already been developed, could save considerable investment.

25. The United Nations recognizes the importance of the international nature of the major basic space science facilities in the region as described in the workshops as South African Astronomical Observatory (SAAO) and Hartebeesthoek Radio Astronomy Observatory (HARTRAO). It recognizes the opportunities offered on a regional basis for Africa in basic space science. The United Nations recommends using the focus and experience to stimulate the development of basic space science in the region through the sharing of facilities.

C. Availability and establishment of scientific facilities

1. Utilization of infrastructural facilities

26. In order to stimulate the utilization of the existing major facilities in basic space science by scientists from developing countries and to enhance their awareness, (a) countries possessing better facilities should be encouraged to open them to developing countries; and (b) developing countries should seek short-term fellowships and travel grants for such purposes.

2. Utilization of ground-based facilities available in developing countries

27. Questions on basic space science require experimental verification beyond the resources of individual nations. Therefore, the development, on a regional basis, of locations in Africa, whose climatic and geographical conditions offer unique opportunities for such work should be considered. These could also serve as a component of a global study.

28. In order to help in the development of space science and technology in Africa, relevant intenational organizations should support (a) the participation of African technology in the space science projects of the major space agencies; and (b) hardware development in African countries for these projects.

D. International cooperation in basic space science

1. International cooperation and internationally coordinated basic space science programmes/projects

29. A regional directory of basic space scientists and institutions in Africa should be published. Information on possible sources of funding for training and research support for the different countries will be collected and included in the directory.

30. The United Nations, recognizing that the benefits of the pursuit of basic space science investigations constitute a prime motive for collaboration between Member States, should therefore support and recommend:

(a) Further expansion and continuation of studies of Equatorial Electrojet (EEJ) and the South Atlantic Geomagnetic Anomaly in the context of regional/international collaboration involving:

(i) Reactivating selected geomagnetic and ionospheric observatories, as well as enhanced support for the networks of such observatories;

(ii) Encouraging active scientists to participate in and organize international meetings;

(iii) Creating national committees for the Committee on Space Research (COSPAR) for those Member States not already belonging to that organization, which is a major focal point for the coordination of studies in the field;

(b) Developing and constructing optical telescopes and radio telescopes with observatory facilities by African countries for use by the basic space scientists of the region;

(c) Augmenting the global coverage of INTERMAGNET by supporting the establishment of three observatories in Sri Lanka, eight in Africa and eight in Latin America and the Caribbean;

(d) Establishing a regional information centre specifically oriented towards astrophysics and atmospheric and geoplanetary sciences for the purpose of:

(i) Disseminating all relevant data obtained under basic space science activities such as remote sensing, atmospheric probing, astrophysics and geophysics to provide vital regional information of fundamental importance for addressing problems related to disaster avoidance and warning;

(ii) Developing a new understanding of the globally important equatorial zone, and therefore developing a plan, in the developing countries, leading to improved resource management and improved living conditions;

(e) Strengthening and reorienting current research activities in the fields of solar-terrestrial, atmospheric and climatic studies, combined with space remote-sensing observations and comparative planetary sciences with participation in the internationally coordinated Global Change and associated programmes such as START, including:

(i) Satellite observations to assess pollutant-rich areas;

(ii) Ground and air truth measurements of solar radiation related to a variety of minor constituents;

(iii) Physical understanding and mathematical modelling of the interlinked processes of global change;

(f) Strengthening current research activities in the fields of astronomy and astrophysics, including:

(i) Experimental, observational and theoretical astrophysics;

(ii) Participation of African astrophysicists in worldwide programmes supported by IAU;

(iii) Systematic galactic and extragalactic observations from equatorial latitudes in the southern hemisphere over the entire electromagnetic spectrum.

31. The participants recognized the difficulties existing in smaller developing countries relating to maintaining and participating in the technological and social developments following naturally from a viable programme in basic space science. They also recognized the problems associated with the relative isolation in which scientists pursue their efforts in those cases. International organizations should therefore support:

(a) The organization of regional connectivity through data networks;

(b) The stimulation of institutional relations between those regional centres of expertise and local institutes to allow the build-up of a national capability to participate in the rapid scientific, technical and associated cultural development in the world;

(c) The training and further development of human resources, to stimulate and enhance the participation, in a balanced development, even of smaller countries;

(d) The active stimulation of students in basic space science by participation in exchange programmes on a regional basis, as well as the exchange of prominent teachers and high-level technicians on a regional basis;

(e) Efforts to create awareness of the importance of basic space science in both decision makers and the general public.

2. Meetings and symposia on basic space science

32. Considering the growing interest and contribution made by several developing countries in basic space science and the need for further encouraging such activities, the United Nations should organize and support international meetings, for in-depth discussions on specific topics of basic space science.

3. Continuation of the Workshop on basic space science

33. In order to assure a continued and coordinated evolution of the important issues raised in the current and the previous workshops, it was proposed to hold future basic space science workshops annually, although in the long run they should be held no more than biennially.

34. The United Nations should inquire into the possibilities for hosting the next basic space science workshop in 1994.

4. Space education

35. Considering that basic space science is not taught at superior levels in many developing countries, relevant international organizations should act to encourage and support:

(a) The introduction of the teaching of basic space science, including experimental techniques, as a part of the curriculum for primary and secondary level education as well as undergraduate and graduate education, by the implementation of basic space science curricula at universities and technical schools;

(b) Formation of research facilities at universities so that motivated students may be encouraged to pursue basic space science research;

(c) Organization of summer schools and other similar orientation programmes to train existing faculty in the physical sciences necessary to teach basic space science;

(d) Exchange of teachers, scientists and students to make use of the facilities in Member States and of the services of organizations such as IAU and COSPAR;

(e) Organization of seminars, workshops and topical conferences within the developing countries for the benefit of teachers, scientists, students and the general public;

(f) Introduction of popular programmes to encourage and support awareness of basic space science, and the coordination of such activities between Member States;

(g) Establishment of programmes ensuring the availability of basic textbooks and more popular information media at the professional and general public levels;

(h) Distribution and acquisition of educational software for basic space science;

(i) Generation of national career opportunities for professionals trained under the above-mentioned programmes, leading to the increased competitiveness of developing countries in the peaceful study and utilization of resources associated with basic space science;

(j) Strengthening of the IAU visiting lecturer programme, in coordination with IAU, with special emphasis on the African continent;

(k) Organization, under the auspices of IAU, of two consecutive, annual, regional African summer schools for teachers in the application of experimental techniques.

5. International core group

36. In order to pursue and follow up the recommendations made during the Workshop, it was decided to constitute a core group, under the auspices of the United Nations (Office for Outer Space Affairs), of international scientists consisting of the following members at the functional and advisory levels:

Functional members: Selection of a group of five members in good standing from the basic space science community and one member from the United Nations Office for Outer Space Affairs;

Advisory members: COSPAR, ESA, IAU, ICTP, Institute for Space and Astronautical Science (ISAS), NASA, TPS and two members from the region of the next Workshop.

37. The creation of the international core group is considered critical to maintaining the impetus generated by the first two workshops on basic space science for developing countries, and will assure the continuity of this important activity in the future.

38. Core group activities:

(a) Review by a Workshop of basic space science developments in the region;

(b) Assurance that the regional benefits of the Workshop are optimized through the selection of the programme;

(c) Maintaining the purely scientific nature of the Workshop.

39. Recognizing the on-going efforts of the Programme on Space Applications to establish regional centres for space science and technology education, the Workshop urges all African member States of the United Nations to give maximum support to this initiative of the United Nations.

Annex I

SUMMARY OF PRESENTATIONS

A. International cooperation in basic space science

The relevance of space science in understanding the planet

1. Space science can play a key role in furthering the understanding of Earth and providing information that is critical to economic development in an ecologically supportable way. One of the main areas within space science, in specific, planetary science, is the field of comparative planetology. Earth is a planet and by comparing and contrasting it to the other planets a deeper and broader insight can be gained of how the Earth works. Specific examples include the following: weather, to which studies of Jupiter, Venus and Mars have contributed; geology, which benefits from a comparison of Venus, Earth and Mars; and the greenhouse effect which is exhibited by Earth, Mars, Titan and, most of all, Venus. Remote sensing of the Earth from space provides information on both natural and human-induced changes. Basic space science is the foundation for the technology to obtain this information and to use it to plan sustainable and ecological development. Finally space science provides a cultural connection between intellectual and economic development.

International cooperation in astronomy: the role of the International Astronomical Union

2. More than any other science, astronomy needs international cooperation to progress because simultaneous observations from many different places are often desirable, while other observations (e.g. of solar eclipses) may be made only from certain places. This need probably accounts for the fact that the International Astronomical Union (IAU) is one of the oldest scientific unions. IAU plays a role in fostering many kinds of international cooperation including, in certain well-defined circumstances, giving assistance with international travel. Some of the things that IAU can and cannot do to help astronomers in developing countries were described in the paper.

Basic space science in Africa

3. The current status of basic space science research in African countries was reviewed. The efforts being made to develop space science research at the University of Nigeria were discussed, as well as the proposed international collaboration on solar seismology. Such international collaboration appears to be the only way forward for African countries. It was emphasized that policy makers in African countries need to be made aware of the importance of space science and its various technological spin offs.

An inter-African astronomical observatory and science park on the Gamsberg in Namibia?

4. The Gamsberg is a table-mountain 120 km south of Windhoek above the Namib Desert at an altitude of 2,350 m above sea-level. In the 1970s, a small astronomical station was established there by the German Max-Planck Society, the owner of the mountain's plateau, but the intended completion of a powerful observatory was not possible at that time for political reasons. The Gamsberg is one of the most suitable sites for an observatory, having a large number of cloudless nights, a dark sky, excellent atmospheric transparency and low humidity. Comparative test measurements have demonstrated that it is of just as good a quality as the well-known astronomical sites in Chile. But the mountain is also qualified for and of interest to other kinds of scientific activities, such as cosmic ray physics, atmospheric research and meteorology, biology and geology. The huge plateau of about 250 hectares offers enough space for various independent installations. The Max-Planck Institute for Astronomy (Heidelberg, Germany) is trying, at present, to initiate development aiming at a new scientific centre on the Gamsberg. But it can only be achieved with international support

and collaboration. The ideal solution would be an inter-African science park. The Government of Namibia, as well as the recently founded Windhoek University, are very much in favour of this project.

An astronomical observatory for Central America: a realistic way of strengthening basic space science in developing countries

5. Modern developments in astronomy and its implications for culture, science and technology in the world have created the necessity of establishing an astronomical observatory equipped with computers, electronics and astronomical new technology for the use and benefit of Central American countries as a way of improving aspects of their lives and reducing the gap with industrialized countries. This project provides a basis for establishing such an astronomical centre, and the paper described the whole process of choosing a place for the observatory after site testing; designs and construction of the observational system and its electronic and computer accessories, as well as those of the buildings and access thereto; the training of Central American scientists and technicians in basic space and astronomical sciences in Central American countries, and the lending of basic astronomical services to these countries. The financial support as well as the operation of this research centre itself were considered in terms of permanent international cooperation to maintain: (a) a critical mass of astronomers in continual scientific production in the region; (b) a place where the international scientific community may gather to make their observations; and (c) an infrastructure through which Central American countries could arrive and remain in the community of space-faring nations to participate in regional astronomical and space programmes.

B. Space science education

Educating electrical engineers in South Africa

6. A presentation was made of the education philosophy of the Department of Electrical and Electronic Engineering at Potchefstroom University, which is one of the oldest and most prestigious universities in South Africa. The University has a second name "Christien Higher Education". The role that this philosophy plays in educating engineers at the University was explored. In the face of severe financial constraints enforced by a negative growth rate of the domestic economy, political instability and global recession, an education policy was developed of training students to gain insight into the physical phenomena that the electrical engineer has to cope with in practice using simple and cheap laboratory projects, but with powerful concepts behind those. The University is able to produce engineers of outstanding quality that are able to compete on a global market with a fraction of the experimental facilities and financial backing that prominent European and American universities have at their disposal.

Basic space science education in Nigeria

7. The role of basic space science in the present curriculum for primary and secondary schools was discussed as well as the future development of space science education at all levels (primary, secondary and tertiary). The importance of educating teachers in basic space science was emphasized. Provision of planetariums in the country could go a long way to help in the education process as well as in popularizing space science.

Space science education in developing countries

8. Among several possibilities of creating necessary awareness and imparting space science education in developing countries, the organization of meticulously planned summer/winter schools offering orientation courses on a variety of topics is envisaged. As an example, details of such a school on the radiative characteristics of the earth-atmosphere system were presented. The model course would include the syllabus covering the fundamentals of radiative transfer mechanisms, interactions of solar and terrestrial radiation with

the Earth's environment and atmosphere, measurement techniques, global observations using satellite and ground-monitoring systems, current scientific problems in the area and scope of further research in the field. The structure and implementation strategy for such a course package was presented.

C. Atmospheric physics

A study of day-to-day variability in the low-latitude geomagnetic variations

9. Magnetic records obtained at the low-latitude geomagnetic observatory of Muntinlupa in the Philippines for the year 1962 were analysed for day-to-day variability. Day-to-day variability has some diurnal and seasonal variation and exists also during the night-time. On quiet days, day-to-day variability has smooth variations while occasional erratic variations characterize disturbed days. Day-to-day variabilities in the three elements, H, D and Z, have certain degrees of correlation with one another on quiet days. It was suggested that day-to-day variability is a reflection of solar quiet day variations, thus suggesting a common cause for the two phenomena.

Comparative analysis of geomagnetic variation in the equatorial zone

10. The quiet day variations in the equatorial zone with time, day and season were presented and analysed for stations near and outside the dip equator, as well as for the equatorial electrojet stations. The results obtained indicate that there is no significant difference between the daily variations of the delineation (D) and vertical components of Earth's magnetic field (Z) at stations near the dip equator and outside the dip equator as well as for the electrojet stations. Conversely, it was found that the daily variations of the horizontal component of the Earth's magnetic field (H) near the dip equator were abnormally higher than those outside the dip equator.

Upper atmospherical research project (in India)

11. Indian scientists have carried out various projects, campaigns, experiments and investigations related to upper atmospheric phenomena. Major contributions have been made using ground-based and rocket-borne experiments. Some of the highlights of the results obtained in the areas of D and E region ionization, equatorial electrojet, F-region irregularities and magnetospheric influence on low latitude ionospheric processes were presented. Outstanding scientific problems in the context of further studies were mentioned. Current facilities available in India for pursuing these research activities were also discussed.

D. Planetary science

The outer solar system and origin of life

12. The outer solar system is the home of the gas giants: Jupiter, Saturn, Uranus and Neptune. In addition to the retinue of moons of these giants there are an assortment of small ice-rich objects in the outer solar systems including Pluto, Charon, Chiron and many long-and-short-period comets. Current theories for the formation of the giant planets must explain why Jupiter and Saturn are rich in hydrogen and helium, being almost solar in composition, while Uranus and Neptune are deficient in hydrogen and helium. Current theories suggest that these planets first formed as a rocky core until they reached a critical size after which rapid accretion of solar nebula gas resulted. The outer solar system is rich in organics. These organics could have played a key role in the origin of life on Earth. Comets are the proposed mechanism for delivering organics from the outer solar system to the early Earth. An alternative suggestion for the organic origin of life is in situ production. This is illustrated in the outer solar system by organic synthesis that is occurring on Titan, the largest moon of Saturn and the only moon with a substantive atmosphere.

Liquid water on Mars

13. The presence of fluvial features on Mars clearly indicates that liquid water has existed on its surface in the past. Liquid water is the key requirement for life and evidence that it has existed on Mars is the main motivation for understanding the climatic history of early Mars with an emphasis on the duration of liquid water habitats in extreme environments. A simple climate model of early Mars was employed in order to estimate the duration of ice-covered lakes after the onset of freezing conditions on Mars. The critical parameter determining the existence of ice-covered lakes is the existence of peak seasonal temperatures above freezing. The peak temperature occurs at the subsolar point at perihelion. It is found that if there were a source of ice to provide meltwater, liquid water habitats could have been maintained under relatively thin ice covers for about 0.5 billion years after mean global temperatures fell below the freezing point.

E. Binary stars

Some aspects of binary-stars astronomy

14. Binary stars may be studied either for the information they give about stellar masses and dimensions, or to learn about the physical interaction between the stars (other than their mutual gravitation). These two kinds of study are to some extent mutually exclusive. To study stellar dimensions, it is necessary to observe systems in which the two stars are well behaved and their spectra and light variations can be easily interpreted. Systems in which interactions occur display irregular light variations that often cannot be uniquely interpreted and their spectra are often distorted by the effects of instability in component stars' atmospheres, or even of matter surrounding the system. It is possible for astronomers having access only to small telescopes to make some contribution to the study of binary systems, especially by photometric observation.

F. The Sun

The chlorine solar neutrino experiment

15. The conventional wisdom that there is a solar neutrino problem and that new solar physics or new neutrino physics is required was examined. Physical and astrophysical implications of the results of solar neutrino detection from the chlorine experiment were discussed. The combined results from the Homestake, GALLEX and Kamiokande experiments leave open the question of whether new neutrino physics or new solar physics may lead to the explanation of the solar neutrino deficit. If the time variation of the argon production rate, as observed at Homestake, is a statistical fluke, the resonant neutrino interactions proposed by the Mikheyev-Smirnov-Wolfenstein effect yield the most attractive solution to the solar neutrino problem. If the argon production rate varies indeed in anticorrelation with the solar activity cycle, the conspiracy between the core of the Sun and its envelope activity must be explained. In this respect, whether there is a chronometer hidden deep in the Sun is still a moot question.

Analytic models for the solar structure

16. A number of analytic models which can describe the gravitationally stabilized core of a solar type star were examined in this paper. A multiparameter model is shown to fit with computer calculations on various structure parameters such as density, mass, pressure and temperature of the Sun. For simplicity, a two-parameter model was discussed in detail for the sake of illustration.

Helioseismology

17. There are a number of interesting aspects of the Sun's internal and surface structure that can be seen in the observed properties of the Sun's normal modes of oscillation. Two examples of these are the speed of sound and the internal rotation. There are other manifestations that have been reported but not yet confirmed, or predicted but not yet observed. Examples here are the abundance of helium in the convection zone and the detection of the internal gravity modes of oscillation. The current situation regarding both classes of work was discussed and exciting opportunities were indicated for the next generation of researchers. These opportunities are open to both space and international networks of ground-level observing programmes.

Direct nuclear reaction mechanism in stellar nucleosynthesis

18. In recent years, the importance of the direct-reaction (DI) mechanism in stellar nucleosynthesis (creation of the elements in stars) has been realized. In this mechanism nuclear reactions proceed as one-step processes. DI may dominate in many nuclear processes of stellar nucleosynthesis, such as f.i. in many solar nuclear reactions, in the famous triple-alpha process leading to the creation of carbon or in nuclear reactions of the s-, r- and p-process involving magic-shell nuclei and nuclei far from stability. The models describing DI (Optical Model, Distorted Wave Born Approximation, Direct Capture) were reviewed and examples of stellar nuclear reactions were given where the experimental data are reproduced excellently by these models. As an interesting example, the triple-alpha process was discussed. In this case, it can be shown, assuming the DI mechanism, that the Universe is extremely fine-tuned for the creation of carbon as well as oxygen and therefore also for carbon-based life. This is due to the fact that a variation of the NN-interaction in the order of only one per mile will lead to a change of the reaction rate for the triple-alpha process by a factor of about 250. The consequences of this result with respect to the "anthropic principle" in cosmology (that our universe is tailor-made for the creation of life) were discussed.

About some measurements done in Honduras during the total solar eclipse of 11 July 1991

19. A morphologic description of the solar photosphere, chromosphere and corona was discussed from a complete sequence of visual and spectroscopic observations made in Amapala, during the total solar eclipse of 11 July 1991, and from the analysis of some emission and absorption lines of the solar spectrum. Also, a comparison of the detected total flux of muons incident over Tegucigalpa on the day of solar eclipse with data obtained years before were presented, along with an analysis of the measurements of the geomagnetic field in Amapala, before and on 11 July 1991, in order to detect any changes associated with the event of the solar eclipse.

G. Ground-based and space-based observations

A new cut-off corrugated horn for astronomical radiotelescope and observable radio sources

20. A new cut-off operation of a corrugated conical horn has been experimentally developed. Effective design of feed within this cut-off yielded 99 per cent efficiency feeding of an astronomical radiotelescope dish. With this super-high efficiency feed system, it is possible to observe some radio sources even with a modest-sized dish.

H. Astrophysics and cosmology

The ROSAT X-ray sky

21. On 1 June 1993, the ROSAT X-ray observatory completed the third year in orbit. Half a year of that time was used to perform an All-Sky Survey leading to the detection of about 60,000 X-ray sources. Since

then, this large database is being used for many statistical studies on different object classes as well as for detailed analysis of individual sources. The remainder of the in-orbit time, ROSAT was operated as an observatory with long exposures to specific sources. A few hundred papers have already been published covering almost all galactic and extragalactic object categories. The paper demonstrated the capabilities of the X-ray instrument on ROSAT discussing selected results from both mission phases.

Restrictions on cosmological models placed by measurement of cosmic background anisotropies by the Cosmic Background Explorer

22. The recent discovery of anisotropies in the cosmic microwave background (CMB) by COBE has spurred a high level of activity in cosmology. Being originated at the remotest epochs of the Universe within reach, CMB is one of the most accurate probes of the early Universe and thus a powerful test for cosmological models. An analysis and interpretation of COBE data were presented. Particular attention was given to the meaning and implications of the structure detected by topological descriptors such as hot spot number and geometry. These results will be interpreted within the "mixing of geodesics" theoretical framework, which predicts elongation of hot spots in an open Friedmann Universe. Limitations and restrictions on the power spectrum of primordial density fluctuations were given and interpreted. Results of a confrontation of the implied power spectrum of COBE with that of the clustering of matter at large scales show that a scale invariant spectrum is not viable.

Observational constraints on the cosmological parameters

23. Latest estimates of the three cosmological parameters, the density parameter, Hubble constant and the cosmological constant were discussed, in particular with regard to observational constraints on their possible values. These observational constraints include limits on the density of baryonic matter from Big Bang nucleosynthesis, estimates of mass density from the dynamics of galaxies and clusters, estimates from the ages of globular clusters and nuclear cosmochronology, constraints from the cosmic microwave background, results from infrared galaxy data and radio source data, and possible estimates from gravitational lensing. Estimates of the cosmological parameters from radio-source data are hampered by the evolution of radio source properties, which are not well understood. An investigation of the effect of assuming a non-zero cosmological constant on the linear-size evolution of radio galaxies was made. It has been found that the inclusion of a non-zero cosmological constant does not significantly reduce the amount of linear-size evolution in the sample used.

The radio luminosity-linear size relation as a test of the quasar/galaxy unification scheme

24. The quasar/galaxy unification hypothesis based on pure orientation has been investigated using the observed linear size (D) - luminosity (P) relation for a sample of radio sources at low frequency. It was found that the quasar D-P slope and intercept exceeded that of radio galaxies by a factor of about 5 and 3, respectively. The observed relation appeared to contradict that expected in a random source orientation hypothesis in which the FRII radio galaxies would be seen as a quasar if their orientation angle is within 44° to the line of sight. The result suggested an intrinsic difference in the size distribution between radio galaxies and quasars even at similar luminosities and redshifts.

Inelastic collision model for optical emission from large-scale jets

25. Apart from the jet of M87, little is known concerning optical emission from astrophysical jets. The number of large-scale jets detected in the optical window is a small fraction of the total number detected in the radio window. Optical emission, however, contains information not available in the radio wavelength and the energy radiated in the optical range could be as important as the part radiated in the radio window for the total energy budget of the jets. Knowledge of the optical properties of jets is expected to lead to

constraints on the energy balance and physical conditions in the jets. An inelastic collision model is proposed as a plausible mechanism for the production of optical emitting electrons seen in some large-scale jets. The target proton density is shown to be readily available through the entrainment of thermal gas as the jets interact and share their momentum with their environment. The optical flux densities predicted by the model for some typical optical jets are in reasonable agreement with the observed values. The model also predicts a relativistic proton flux from the galactic centre with spectral index $\Gamma \leq 2$.

Consequences of asymmetric baryonic production in astrophysical sites

26. A new paradigm in asymmetric baryonic production was examined in this paper. While the ratio of the flux of antiprotons to protons in cosmic rays lies within 10{-3} it is at the level of 10{-10} in the local group of galaxies. The production mechanism for the antiproton flux dictates the level relative to protons. Production mechanisms for antibaryons in various astrophysical sites, namely black holes, supernova and active galactic nuclei, as well as galaxies, were discussed. The measured and predicted values of the corresponding antibaryon-baryon ratios or P/P, ñ/n, He/He are in fair agreement, hence the assertion that matter and antimatter are of the same galactic or extragalactic origin and that possible asymmetries could be due to broken symmetry during the early evolution of the Universe, CP violation effects or the non-equality of matter-antimatter production from different decay processes.

Preliminary theoretical development of a unified field theory for ground and remote sensing in low latitudes

27. From the numerous space experiments and the applications of space research so far, it is obvious that a coordinated combination of both ground and remote sensing yields the most useful results. For about 25 years at Ibadan, Nigeria, scientists have been involved in both theoretical and experimental work in the use of electromagnetic fields propagated in low latitudes for solid Earth physics research in the south-south region. In this paper, the application of a unified field theory of two natural fields was introduced, to tackle problems of coordinating ground and remote sensing in low latitudes. In this preliminary work, the field equations for the unified field theory are presented in their simplest form in order to emphasize the importance of a coordinated combination of both ground and remote sensing space research in the south-south region of the world.

Measurement of diffuse solar radiation on a horizontal surface at Ilorin, Nigeria

28. The development of solar energy devices and studies of atmospheric radiative transfer often require the knowledge of diffuse, direct and global solar radiation. In pursuance of this need, measurements of diffuse solar radiation have been made and are reported herein. Using an Eppley "black and white" pyranometer with an improvised shadow ring and a digital recorder/printer, the diffuse radiation intensity H_d falling on a horizontal surface has been measured at Ilorin (8°30'N, 4°46'E), Nigeria, for a period of six months commencing in February 1993. The radiometer was calibrated using two different methods which gave constants of 8.54 ± 0.02 V/Wm$_{(-2)}$ and 0.150 ± 0.002 counts min$_{(-1)}$/Wm$_{(-2)}$. Calculations using both of these constants yield results which agree closely to within $\pm$ 3%. The data, after the necessary correction for the shadow-ring effect, were analysed to obtain the diurnal and monthly variations of the diffuse radiation parameters H_d, H_d/H and the standard deviations of H_d/H, where H is the corresponding global radiation measured for the same location and time as H_d. The results whose monthly variations are significant, have been compared with those achieved by other workers.

Annex II

PROGRAMME OF THE WORKSHOP

DATE/TIME	SUBJECT	SPEAKER
17 OCTOBER 1993		
	Registration	
18 OCTOBER 1993		
	Inauguration and opening ceremony	
	Chairperson: D. Sarumi (Nigeria)	
9.30-9.50 a.m.	Welcome address of the Vice-Chairperson of NASENI	G. O. Ezekwe
9.50-10.10 a.m.	Address by the representative of the United Nations	A. A. Abiodun
10.10-10.25 a.m.	Goodwill message by the Vice-Chancellors of the University of Nigeria and Obafemi Awolowo University	O. K. Udeala and Wale Omole
10.25-10.40 a.m.	Remarks by the Chief Executive and Managing Director of NITEL PLC	E. C. Omeata
10.40-11.10 a.m.	Opening address by the Honourable Secretary for the Ministry of Communications	Chief Dapo Sarumi
11.10-11.20 a.m.	Keynote address: Importance of basic space science for Africa	E. E. Balogun (Nigeria)
11.20-11.40 a.m.	Vote of thanks	L. I. Onuora (Nigeria)
	International cooperation in basic space science	
	Chairperson: H. J. Haubold (United Nations)	
2.30-3.00 p.m.	Relevance of space science in understanding our planet	C. P. McKay (USA)
3.00-3.30 p.m.	International cooperation in astronomy	A. H. Batten (Canada)
3.30-4.00 p.m.	An inter-African astronomical observatory and science park on the Gamsberg in Namibia?	H. Elsaesser (Germany)
4.15-4.45 p.m.	The need for a medium sized astronomical facility in the Asian-Pacific region	K. Ch. Leung (USA/Thailand)

4.45-5.15 p.m.	An astronomical observatory for Central America: A realistic way of strengthening basic space science in developing countries	M.C.P. de Carias (Honduras/Spain)
5.15-5.45 p.m.	Basic space science in Africa: The Nigerian experience	L. I. Onuora (Nigeria)
6.00 p.m.	Working Group session Chairperson: W. Wamsteker (ESA)	

19 OCTOBER 1993

9.00-09.30 a.m.	Regional Astronomical Project: Latin America and the Caribbean	J. Sahade (Argentina)

Space science education

Chairperson: E. E. Balogun (Nigeria)

9.30-10.00 a.m.	Educating electrical engineers in South Africa	J. Rens (South Africa)
10.00-10.30 a.m.	Basic space science education in Nigeria	M. O. Asogwa (Nigeria)

Chairperson: E. Oni (Nigeria)

10.45-11.15 a.m.	Space science education in developing countries	S. C. Chakravarty (India)

Atmospheric physics

11.15-11.45 a.m.	A study of day-to-day variability in the low-latitude geomagnetic variations	A. B. Rabiu (Nigeria)
11.45 a.m.-12.15 p.m.	Comparative analysis of geomagnetic variations in the equatorial zone	F. N. Okeke (Nigeria)

Chairperson: S. O. Ogunade (Nigeria)

12.15-12.45 p.m.	Upper atmospheric research project (in India)	S. C. Chakravarty (India)
12.45-1.15 a.m.	Upper atmospheric research satellites	F. N. Onyango E. K. Anyamba (Kenya)
2.30-3.00 p.m.	Some aspects of basic space science for satellite communication	G.O. Ajayi (Nigeria)

3.00-3.30 p.m.	Measurement of solar short-wave and long-wave radiation at Ile-Ife, Nigeria	J.A. Adedokun (Nigeria)
3.30-4.00 p.m.	Optical astronomy in South Africa	R.S. Stobie (South Africa)
4.15 p.m.	Working Group session Chairperson: W. Wamsteker (ESA)	

20 OCTOBER 1993

Planetary science

Chairperson: A. H. Batten: (Canada)

9.00-9.45 a.m.	The inner solar system	A. Ocampo (USA)
9.45-10.15 a.m.	The outer solar system and origin of life	C. P. KcKay (USA)
10.15-10.30 a.m.	Liquid water on Mars	W. L. Davies (USA)
10.30-10.45 a.m.	Overview of upcoming missions	C. P. McKay, A. Ocampo (USA)

Binary stars

Chairperson: W. Wamsteker (ESA)

11.00-11.30 a.m.	Use of IUE data for advancing our knowledge of interacting binary stars	J. Sahade (Argentina)
11.30 a.m.-noon	Some aspects of binary-star astronomy	A. H. Batten (Canada)
noon-12.30 p.m.	Contact systems with large temperature differences between components	K. Ch. Leung (USA/Thailand)

The sun

Chairperson: H. A. Hill (USA)

12.30-12.45 p.m.	The chlorine solar neutrino experiment	H. J. Haubold (United Nations)
12.45-1.15 p.m.	Analytic models for solar structure	A. M. Mathai (Canada)

Chairperson: A. Ocampo (USA)

2.30-3.00 p.m.	Helioseismology	H. A. Hill (USA)
3.00-3.30 p.m.	Direct nuclear reaction mechanism in stellar nucleosynthesis	H. Oberhummer (Austria)
3.30-4.00 p.m.	About some measurements done in Honduras during the total solar eclipse of 11 July 1991	M.C.P. de Carias (Honduras/Spain)

Ground-based and space-based observations

Chairperson: H. Oberhummer (Austria)

4.15-4.30 p.m.	International Ultraviolet Explorer (IUE)	W. Wamsteker (ESA)
4.30-5.00 p.m.	The role of new digital networks for space science applications - A chance for developing countries	D. Flasch (Germany)
5.00-5.30 p.m.	Radio astronomy in South Africa	G. Nicholson (South Africa)
5.30-6.00 p.m.	A new cut-off corrugated horn for astronomical radiotelescopes and observable radio sources	F.C.C. Anyaegbunam (Nigeria)
6.15 p.m.	Working Group session Chairperson: C. P. McKay (USA)	

21 OCTOBER 1993

Cosmology/astrophysics

Chairperson: A. M. Mathai (Canada)

9.00-9.45 a.m.	The ROSAT X-ray sky	W. Voges (Germany)
9.45-10.30 a.m.	Restrictions on cosmological models placed by COBE's measurement of cosmic background anisotropies	S. Torres (Colombia/Italy)
10.45-11.15 a.m.	Observational constraints on the cosmological parameters	L. I. Onuora (Nigeria)
11.15-11.45 a.m.	The radio luminosity-linear size relation as a test of the quasar/galaxy unification scheme	A. A. Ubachukwu (Nigeria)

11.45 a.m.-12.15 p.m.	Inelastic collision model for optical emission from large-scale jets.	M. W. Anyakoha (Nigeria)
12.15-12.45 p.m.	Consequences of asymmetric baryonic production in astrophysical sites	G. Anene (Nigeria)
12.45-1.15 p.m.	Preliminary theoretical development of a unified field theory for ground and remote sensing in low latitudes	E. A. Oni (Nigeria)
1.15-2.30 p.m.	Measurement of diffuse solar radiation on a horizontal surface at Ilorin, Nigeria	M. G. Iziomon (Nigeria)

22 OCTOBER 1994

Conclusion

9.00 a.m.-1.15 p.m. Working Group session
Chairperson: W. Wamsteker (ESA)

2.45-4.00 p.m. Closing session

Chairpersons: A. A. Abiodun (United Nations)
E. E. Balogun (Nigeria)
W. Wamsteker (ESA)

1. Report by Chairperson of the Working Group
2. Adoption of the report
3. Closing remarks